MULTI-PRODUCT RETAILERS AND THE SALE PHENOMENON

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ABSTRACT

Two common features of retailing are that each retailer sells many different products, and that pricing strategies differ across these products. This paper extends previous theoretical research on single-product retailer competition to a multi-product setting. Specifically, we model a retailer's optimal pricing strategy for perishable and non-perishable items. We find the intuition used to explain pricing dynamics for non-perishable items in single-product models generalizes to the multi-product setting. Moreover, within the multi-product setting, we show that because "sales" on alternative goods can be used to attract customers, price changes for the non-perishable good will have an impact on perishable pricing. In addition, the multi-product setting allows us to generate a richer set of implications than does the single product case, some of which we empirically examine. Consistent with the theory, price changes are larger in magnitude for the non-perishable item examined (peanut butter) than for the perishable good (margarine). Further, perishable and non-perishable price changes are negatively correlated, as the theory predicts. We view this evidence as suggesting that retailers' pricing strategies are related in predictable ways to product characteristics, such as consumers' storage costs.

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I. Introduction

Empirical and theoretical treatments of retailing (and distribution more generally) have been relatively scarce in the economics literature. At the same time, government antitrust actions are increasingly directed toward such industries.[1] Understanding what retailers do, and how they compete seems essential to developing appropriate policies towards these industries.

One well-documented aspect of retailer behavior is that many products are subject to sales.[2] Moreover, the frequency and magnitude of *sales* differ across the set of goods that most retailers sell. Several previous papers (for example, Sobel, Pesendorfer, and Varian) have sought to explain the frequency and magnitude of *sales* for a single-product retailer. The primary goal of this paper is to generalize these single-product models to an environment in which each retailer sells multiple products. Specifically, we determine equilibrium pricing behavior over time in a model in which competing retailers sell two goods, one of which can be inventoried by consumers (non-perishables), one of which cannot (perishables). We show that one important aspect of the single-product models carries through to the multi-product case; periodic sales on the non-perishable could enable the retailer to price discriminate. We also show that changes in the price of the non-perishable induce the retailer to change perishable prices as well, so that both prices will change over time. As such, our model generates implications for the relationship between the prices for the two kinds of goods that cannot be obtained in single-product models. For example, we show that price movements for the two goods should be negatively correlated, and that price discounts for non-perishables goods should be deeper, but less frequent.

We test the predictions of our model using publicly-available store-level scanner data on prices from supermarkets in two Midwestern cities. One test is a comparison of the frequency and magnitude of sales for one non-perishable product (peanut butter) and one perishable product (stick margarine) over a two-year period.[3] Consistent with the model, we find that price discounts for peanut butter are less frequent but of larger magnitude than discounts for stick margarine. Further, perishable and non-perishable price changes are negatively correlated, as the theory predicts.

We view this evidence as suggesting that price discrimination through intertemporal price changes is one function served by sales in the food retailing business. To the extent these findings are confirmed in future research, they would have several implications for interpreting empirical results. For example, they would suggest that for certain types of goods, the elasticities derived from estimating demand using contemporaneous price and quantity data will not answer the question of how consumption would change if the entire distribution of retail prices changed (e.g., because of a change in wholesale price). Elasticities derived in this manner can be thought of as *purchasing* elasticities, measuring the response of consumer buying behavior to temporary changes in price. This can be quite different from *consumption* elasticities (which measure the response of purchases to permanent price changes) if purchasing behavior has an intertemporal component (due to, e.g., consumer inventorying). To a manufacturer contemplating a change in its wholesale price, or an antitrust agency evaluating the effect of a merger of two manufacturers, it is the consumption elasticity that is relevant to assessing the impact of a price change.

II. The Sales Phenomenon

Sales, in the sense of periodic, temporary reductions in specific product prices are a feature of supermarket competition, but one which has not generated a great deal of economic research. Figure 1 illustrates a typical pattern of prices for a good subject to sales. As illustrated there, peanut butter prices tend to remain unchanged for long periods of time, then experience significant, short-lived reductions. Table 1 (reproduced from Hosken, Matsa and Reiffen) presents more systematic evidence on this pattern. The data used there represent retail prices on a variety of products sold in grocery stores, for 30 metropolitan areas. The "Proportion at Mode" column of table 1 presents statistics for specific products in different categories concerning the percentage of monthly observations within each year that are exactly equal to that product's modal price for that year. With the exception of eggs and lettuce, the products' prices are equal to their modal value at least 50% of the time. The next column contains information on the prices that are not equal to the annual modal. Specifically, the statistic there is the ratio of prices below the mode to prices above the mode. In each product category, the difference between the number of downward deviations from the mode is higher than the number of upward deviations by a statistically significant amount. Thus, the data suggests that most products have a "regular" price, and irregular downward deviations from that price.[4]

To understand this behavior we develop a model which draws primarily from work by Conlisk, Gerstner and Sobel. The basic intuition in their model is that consumers differ in demand elasticity and in their willingness to wait (which is analytically similar to differences in costs of inventorying). If these differences are correlated (low elasticity customers are also less willing to wait), a seller can price discriminate by making high-elasticity customers wait for low prices. Hence, *sales* arise because these periodic price reductions lead to a large volume of purchases by high-elasticity customers, while allowing the seller to charge high prices most of the time to low-elasticity customers.

The Conlisk, Gerstner, and Sobel model captures this intuition in a tractable way. In their model, there are two classes of consumers: One class has a high reservation value to consuming the good (α_H) and an infinite discount rate, and a second class has a lower value (α_L) and a finite discount rate. The seller cannot determine an individual consumer's type and hence must charge the same price to everyone in each period. One cohort of each type of consumer enters the market in each period, and then each consumer departs the market as soon as she purchases one unit of the good. That is, consumers still in the market with a reservation value below that period's market price do not purchase during that period but remain willing to buy (at a sufficiently low price) in future periods.

Conlisk, et al. show that given these consumer preferences, a monopoly retailer of the good would charge α_H for a number of periods, thereby capturing the value the high-value consumers place on the product. During any period in which the retailer charges α_H, low-value consumers do not make a purchase but remain willing to buy in the future if price declines sufficiently. Eventually, as the number of unsatisfied low-value consumers grows, it becomes profitable to lower prices sufficiently to sell to the large group of low-value consumers that have "accumulated." By having a sale, the retailer's profits from selling to high-value consumers falls (by α_H-α_L), but is offset by the high volume of sales to low-value consumers. Thus, Conlisk, et al. provide an explanation of periodic sales; whereby a retailer lowers its price for a short time, even though its costs and the number of new high-value consumers has not changed.[5] In this model, sales can be seen as a means of price discriminating against impatient, high-value consumers.[6]

Sobel extends this model to the case of multiple retailers. Sobel interprets the high-value consumers as not only willing to pay more for the good, but also as being loyal to one retailer. Thus, with J identical retailers, by charging α_H each retailer can earn revenues of (α_H/J) times the number of high-value customers. In addition to being more willing to wait than high-value consumers (as in Conlisk, Gerstner, and Sobel), low-value consumers are willing to buy at whichever retailer offers the lowest price. The primary difference between this model and the monopoly model is that low-value consumers do not accumulate in the same way when a retailer charges a high price. Here, the low-value consumers accumulate in aggregate, but they react to a lower price charged by any retailer. Hence, an individual retailer may miss the opportunity to sell to the accumulated low-value consumers after charging α_H for a number of periods because the low-value consumers may have purchased elsewhere. In the multiple retailer model, each retailer faces the same basic decision; is it preferable to sell to the group of loyal customers at a high price, or cut price and sell to both these customers and the accumulated non-loyal consumers before a rival does? As the length of time since any retailer had a sale increases, the number of non-loyal consumers rises as well, and this later option becomes more attractive. In the equilibrium in Sobel's model, all retailers charge α_H for a number of periods, until the expected profit from selling to the accumulated low-value consumers at a low price equals the profit from selling to the loyal customers at a high price. At this point, each retailer chooses a price from a continuous distribution of prices.

The basic characteristics of the equilibrium in Sobel resembles the monopoly case; retailers charge α_H when the number of non-loyal customers is small, but as the number grows, it eventually becomes profitable to reduce price in order to attract the non-loyal customers. The key difference between the monopoly and multiple retailer equilibria is that sales occur more frequently (and at lower prices) with multiple retailers. Finally, one can extend the model to show that the difference between the monopoly and multiple retailer cases is a general one. That is, a reduction in the number of competing retailers has the effect of reducing the frequency and depth of sales.

Pesendorfer both simplifies and generalizes the Sobel model. The simplification is that he assumes low-value customers do not behave strategically - which is to say that they buy whenever price is below α_L.[7] The generalization is that Pesendorfer allows some portion of low-value consumers to be store-loyal. The Pesendorfer model is formally equivalent to a model in which both types of consumers consume one unit of the good in every period (rather than exit the market as soon they purchase one unit), but the low-value consumers consume from their own inventory whenever the price is above α_L.[8]

While this model explains price discounts for goods that can be inventoried, or goods that are infrequently purchased, it does not explain discounts for perishable goods that are frequently purchased and not inventoried, such as dairy products and produce. However, the evidence (see Section IV) suggests that prices of these items also vary considerably over time. Varian provides a related explanation for periodic sales of these products. As in Sobel and Pessendorfer, Varian assumes that some customers are store loyal (buying from their preferred retailer as long as that retailer's price is below the consumer's reservation price), and others buy from the store with the lowest price. Retailers then choose between obtaining a high price, and selling only to store-loyal customers, or charging a "low" price and potentially selling to non-loyals as well. Varian shows that the only symmetric equilibrium features mixed strategies, where all retailers choose their price from a continuous distribution.

Note that the reason for sales in the Varian model is quite different from the reason in Conlisk, Gerstner, and Sobel. In Varian, sales result from competition between imperfectly-competing retailers; a monopoly retailer would not vary price. In contrast, the Conlisk, Gerstner, and Sobel model is a monopoly model, and sales are a means of price discrimination. Sales in the Sobel and Pesendorfer models combine elements of both explanations; price movements reflect both competition and a desire to price discriminate.

III. Sales and Multi-Product Retailers

The models described in the previous section all dealt with how a single-product retailer would adjust his prices over time. The phenomenon these models seek to explain is the pattern of prices illustrated in figure 1. As shown there, peanut butter prices tend to remain constant for long periods, followed by brief periods of lower prices, followed by a return to their initial levels. This pattern is common for many of the goods sold in supermarkets. In evaluating whether these models explain retailer pricing behavior, it is important to consider whether these results also hold for multi-product firms such as supermarkets. In this section, we analyze competition between multi-product retailers. Specifically, we assume each retailer sells two products; one non-perishable (for which there is a potential for price discrimination) and one perishable, for which there is no such potential. This allows retailers to use one product to compete with rivals, while reserving the other for discriminating between high-value and low-value consumers. We show that, as in the Conlisk, Gerstner, and Sobel model, the desire to price discriminate results in periodic sales on the non-perishable product. The model also explains price movements for perishable products, as the prices of these products are adjusted to offset changes in non-perishable prices. In contrast to Varian's explanation, this implies that there will be mass points in the pricing distribution for such products.[9] In addition, modeling retailers as multi-product sellers generates additional implications for prices. For example, we show that prices for perishable and non-perishable goods should vary inversely at each store.

An important aspect of the nature of multi-product retailers is that most consumers buy an array of goods each time they visit certain kinds of retailers (especially supermarkets). Our model incorporates this feature by assuming that consumers know all of the relevant prices before visiting any outlet, and prefer to shop at one store in each period. At the same time, if price differences on individual goods are sufficiently great across stores, some consumers may find it worthwhile to shop at two stores. It follows that retailers compete for customers by attempting to offer the most attractive set of prices.

In analyzing what constitutes the most attractive prices, it is necessary to consider the number of units of a good that a consumer may purchase during each visit. Of particular interest to us is whether a consumer can economically buy more units of a good than she plans to consume in that period, inventorying a portion for later consumption. To the end, we designate one of the two goods as a non-perishable, and the other as a perishable. The key difference between perishable and non-perishable goods in our model is that, at some cost, non-perishable goods can be inventoried by the consumer, whereas perishable goods have to be purchased each period.[10] All stores sell the same assortment of non-perishable goods and perishable goods. We refer to the non-perishable as N, and the perishable as P.

In both the Sobel/Pesendorfer and Varian models, there are two types of consumers; those that are store-loyal and those that compare prices across stores. While we retain the idea from this work that there are loyal consumers and shoppers, we depart from it by changing one aspect of how shoppers choose. In Sobel, Pesendorfer and Varian, all non-loyals shop at the same retailer; the one offering the lowest price. This leads to a discontinuity in marginal revenue (i.e., a large increase in a retailer's quantity sold if his price is slightly below his rivals' prices), which in turn leads to Varian's result that there are no mass point in the pricing distribution. In contrast, we assume non-loyal consumers are heterogeneous with respect to their preferences among retailers.[11] We represent this by assuming there are two retailers, and that consumers are located (either physically or metaphorically) on a line between them.[12] Specifically, we assume that the two retailers are located on either end of a line segment, with the non-loyal consumers located with uniform density on that line segment. Each consumer decides which retailer(s) to visit based on the cost of traveling to the two retailers, and the prices offered by each. Transportation costs are assumed to be T for the entire line segment, so that a consumer located 1/4 of the line away from retailer 1 faces transportation costs of T/4 to reach retailer 1 and 3T/4 to reach retailer 2. These assumptions enable us to have continuous marginal revenue, and also mean that both retailers will typically gain non-zero market share of non-loyals in each period.

With this one exception, we make the same assumptions as in the literature described in the previous section. Specifically, as in all of these models, we assume all consumers have a unit demand for consuming each good in each period as long as the price of the good is below their reservation value for the good, and the seller cannot determine an individual consumer's type. In the Sobel model, store-loyals have a sufficiently high cost of waiting (or equivalently, of storing goods) such that only non-loyals choose to wait for lower prices. To make this distinction as clear as possible, we assume that store-loyals have infinite storage costs, and non-loyals have zero storage costs (any significant difference in customer's storage cost is sufficient for our purposes). Sobel also assumes that the value store-loyal customers place on the good (α_H) is higher than the value that non-loyals (α_L) place on it. In contrast, in Varian, all consumers have a reservation value of β for the good. We combine these assumptions, by allowing non-loyals to have a reservation value of α_L for the non-perishable and β for the perishable. In contrast, store-loyal customers have a reservation value of α_H to buying the non-perishable at their preferred store, and β to buying the perishable at their preferred store. This implies the following about consumer behavior: Letting P_P be the price of the perishable and P_N the price of the non-perishable at her preferred store, a store-loyal customer will make one of four choices in any period;

if $P_N > \alpha_H$ and $P_P > \beta$	buy nothing
if $P_N \leq \alpha_H$ and $P_P > \beta$	buy one unit of the non-perishable only
if $P_N > \alpha_H$ and $P_P \leq \beta$	buy one unit of the perishable only
if $P_N \leq \alpha_H$ and $P_P \leq \beta$	buy one unit of each good

The non-loyal customers make one of 5 choices. Considers a customers who buys M units of the non-perishable whenever its price its below α_L (see footnote 14). If such a customer were located at point x, her choices would be

-if min $[P_N^1 + Tx/M, P_N^2 + T(1-x)/M] > \alpha_L$ and min $[P_P^1 + Tx, P_p^2 + T(1-x)] > \beta$	buy nothing
-if min $[P_N^1 + Tx/M, P_N^2 + T(1-x)/M] \leq \alpha_L$ and min $[P_P^1, P_p^2] > \beta$	buy multiple units of the non-perishable at retailer 1 if $P_N^1 + Tx/M < P_N^2 + T(1-x)/M$, and buy them at retailer 2 if the inequality is reversed.
-if min $[P_N^1, P_N^2] > \alpha_L$ and min $[P_P^1 + Tx, P_p^2 + T(1-x)] \leq \beta$	buy one unit of the perishable at retailer 1 if $P_p^1 + Tx < P_p^2 + T(1-x)$, and buy it at retailer 2 if the inequality is reversed.
-if min $[P_N^1, P_N^2] < \alpha_L$, min $[P_P^1, P_p^2] < \beta$ and $T > P_P^1 - P_p^2$.	buy the perishable and/or multiple units of the non-perishable at whichever store offers the greatest consumer surplus (assuming it is positive).
-if the non-perishable is cheaper at one retailer and the perishable at the other, and $T > P_P^1 - P_p^2$ (assuming the low prices plus transportation costs are below α and β respectively)	buy the perishable at one retailer, and the non-perishable at the other retailer.

The fourth and fifth options illustrate an important component of shopping in our model. A store-loyal consumer's decision rules regarding her purchases of the two products are independent; she buys one unit of good i at her preferred store if good i's price is below her reservation value for good i, without reference to good k's price. In contrast, the purchasing decisions for the two goods are linked for non-store loyal consumers. Because these consumers prefer to buy both goods at the same store, their decision as to which goods to buy are made jointly. For example, if the non-perishable is cheaper at retailer 1 and less than α_L (i.e., $MP_N^1 + Tx < MP_N^2 + T(1-x)$), but the perishable is cheaper at retailer 2 (and $T > P_P^1 - P_p^2$), the consumer must compare the surplus offered by each store's set of prices in determining what to buy.

To reduce notational complexity, we interpret α_L, α_H and β as the difference between the consumer's reservation value and the constant marginal cost of selling the good, so that we normalize the retailers' cost to zero. Additionally, we normalize the number of customers to one. Let γ (where $\gamma < 1$) of customers be store-loyal, and $(1-\gamma)$ non-loyals. Retailers are assumed to be symmetric, so that $\gamma/2$ are loyal to each store.

Each retailer's profit depends on the quantity sold to each of the two groups and the prices charged. As discussed above, as long as $P_P^j \leq \beta$ and $P_N^j \leq \alpha_H$, customers loyal to retailer j will buy both products at that store. Indeed, if retailers only cared about selling to store-loyals, they would always charge $P_P = \beta$ and $P_N = \alpha_H$.[13] The reason that retailers might offer lower prices is to attract non-loyals. A retailer's sales to non-loyals depends on both the prices he charges and the prices charged by his rival. In particular (temporarily setting aside the potential for consumers to buy one product from each retailer), a consumer will buy from retailer 1 if the consumer surplus she obtains from retailer 1 exceeds the consumer surplus from retailer 2 . The consumer surplus for a non-loyal located at point X is $\beta - P_p + M \min(0, \alpha_L - P_N) - TX$. To conform with the models described in the previous section, we assume these consumers buy a sufficient quantity of the non-perishable to replace the amount they consumed since the previous sale, so that M-1 is the number of periods since the previous sale.[14] This means that if $P_p < \beta - T$, and $\alpha_L < P_N \leq \alpha_H$, retailer 1's profits are

$$\Pi_1 \;\; \frac{\gamma}{2}(P_P^1 \;\; P_N^1) \quad\; (1 \;\; \gamma)XP_P^1 \qquad\qquad (1)$$

Where X defines the marginal non-loyal consumer (i.e., the consumer that receives equal surplus from both retailers) . If retailer 2 also sets $P_p < \beta -$ T, and $P_N > \alpha_L$, X can be written

$$X \;\; \frac{1}{2} \;\; \frac{P_P^2 \;\; P_P^1}{2T} \qquad\qquad\qquad\qquad (2)$$

That is, the location of the marginal consumer is determined by perishable prices only. If instead, retailer 1 sets $P_p < \beta$ and $P_N < \alpha_L$, such that $(\beta - P_p) + M(\alpha_L - P_N) > T$, then his profits are

$$\Pi_1 \;\; \frac{\gamma}{2}(P_P^1 \;\; P_N^1) \quad\; (1 \;\; \gamma)X \;\; [P_P^1 \;\; MP_N^1] \qquad\qquad (3)$$

Where X is once again the location of the marginal consumer.

The question we seek to answer is how the prices of the two goods vary over time. To address this, we need consider retailer profitability in different potential equilibria.

1. Both retailers set $P_p < \beta -$ T/2, and $P_N > \alpha_L$ (the no sale/ no sale or N/N case),[15]
2. Both retailers set $P_p < \beta$ and $P_N < \alpha_L$, such that $(\beta - P_p) + M(\alpha_L - P_N) > T/2$ (the S/S case),
3. One retailer sets $P_p < \beta$ and $P_N > \alpha_L$, such that $(\beta - P_p) + M(\alpha_L - P_N) > T$, and the other sets $P_p < \beta -$ T/2, and $\alpha_L < P_N$ (the NS/S case).
4. Each retailer has a sale on the non-perishable with a probability which is between 0 and 1.

To determine each retailer's profitability, we first calculate the price in each of these cases.

Pricing:

1. N/N. If both retailers charge greater than α_L for the non-perishable, then retailer profits are given by equation (1) (with 1-X replacing X for retailer 2). It is easy to see that conditional on $P_N > \alpha_L$, profits are maximized at $P_N = \alpha_H$. To determine the profit-maximizing P_p, we take the derivative of (1) with respect to P_p^1, and recalling the definition of X from equation (2),

$$\frac{\Pi_1}{P_p^1} \qquad \frac{\gamma}{2}\,(1\;\;\gamma)[X\;\;P_p^1\frac{X}{P_P^1}] \qquad \frac{\gamma}{2}\,(1\;\;\gamma)(\frac{1}{2}\;\;\frac{P_p^2\;\;2P_p^1}{2T})$$

setting this equal to zero, and using the fact that retailer 2 has the same first-order condition, we find that $P_p^1 = P_p^2 = T/(1-\gamma)$ (assuming $[1/(1-\gamma) + 1/2]T < \beta$). Since $P_p^1 = P_p^2$, it follows that $X = ½$.

2. S/S. If both retailers charge less than α_L, their profits are given by equation (3) (again, with 1-X replacing X for retailer 2). In this case,

$$X\;\;\frac{1}{2}\;\;\frac{M(P_N^2\;\;P_N^1)\;\;P_P^2\;\;P_P^1}{2T}$$

The symmetric equilibrium prices are $P_N^1 = P_N^2 = (T - \beta)/M + \gamma T/((1-\gamma)M^2)$, $P_P^1 = P_P^2 = \beta$. Again, since both retailers charge the same prices, $X = ½$ (derivation available from authors).

3. S/N. In this case, retailer 1's profits are given by (3), while retailer 2's profits are given by (1) (again with 1 - X replacing X for retailer 2's profits). This also implies

$$X\;\;\frac{1}{2}\;\;\frac{M(\alpha_L\;\;P_N^1)\;\;P_P^2\;\;P_p^1}{2T}$$

The resultant equilibrium prices are (derivation available from authors).

$$P_N^1\;\;\frac{2\alpha_L}{3}\;\;\frac{T}{M}\;\;\frac{\gamma T}{3M(1\;\;\gamma)}(\frac{1}{M}\;\;1)$$

$$P_P^1\;\;2T\;\;\frac{\gamma T}{3(1\;\;\gamma)}[\frac{1}{M}\;\;2]\;\;\frac{M\alpha_L}{3}$$

$$P_P^2\;\;T\;\;\frac{\gamma T}{3(1\;\;\gamma)}[\frac{1}{M}\;\;2]\;\;\frac{M\alpha_L}{3}$$

and $P_N^2 = \alpha_H$.

4. Mixed Strategy Equilibrium

As discussed below, it is possible that for M sufficiently large, a symmetric, mixed-strategy equilibrium will emerge. In that equilibrium, both firms put the non-perishable on sale with probability R, and charge α_H for it with probability 1-R. That is, with probability R each retailer sets $P_P = \beta$ and

$$P_N \ \frac{(2\ R)(1\ R)M}{(2\ R)(1\ R)M^2\ R(1\ R)}[\frac{T}{(2\ R)(1\ \gamma)M}(\frac{1\ R}{1\ R}\ \frac{\gamma\ M\ M\gamma}{M})\ \frac{(1\ R)\alpha_L}{2\ R}\ \frac{\beta}{M}(\frac{R(1\ R)}{(2\ R)(1\ R)}\ 1)]$$

With probability 1-R, the retailer sets $P_N = \alpha_H$ and sets

$$P_P \ \frac{R(1\ R)\alpha_L}{M[(2\ R)(1\ R)M\ R(1\ R)]}\ \frac{T}{1\ \gamma}[\frac{2M\ R\gamma(1\ M)}{(2\ R)(1\ R)M^2\ R(1\ R)M}]$$

Comparing the prices that result in each case, we see that price for the two goods will vary inversely. For example, moving from the case in which neither retailer has the non-perishable on sale to the case in which they both do, we see that P_N falls, but P_p rises. That is, when P_N is "low", a retailer need not use P_P to attract non-loyals.

Equilibrium:

Given the prices that result in the four cases described above, we next consider which of these four cases will emerge in equilibrium. Table 2 portrays the payoffs to the two firms associated with each pair of actions. Note that given the prices described above, equilibrium profits will vary with M except in the N/N equilibrium.

		retailer 2's action	
		sale	no sale
retailer 1's actions	sale	Π_{SS}, Π_{SS}	$\Pi_{S,N}, \Pi_{N,S}$
	no sale	$\Pi_{NS}, \Pi_{S,N}$	$\Pi_{N,N}, \Pi_{N,N}$

Table 2

where Π_{ij} (where i and j can equal N or S) is the profit to firm 1 when it takes action i and firm 2 takes action j; for example, Π_{SN} is firm 1's profit when it puts the non-perishable on sale and its rival does not. The first profit listed in each entry in Table 2 is retailer 1's profits and the second is retailer's 2 profits.

In the Sobel and Pessendorfer models, the dynamic pattern in prices requires that it is not profitable to put the non-perishable on sale if it was on sale in the previous period and your rival does not have a sale. In context of the multi-product model developed here, the analogous condition is $\Pi_{NN} > \Pi_{NS}$ when M = 1, or

$$\frac{\gamma\alpha_H}{2} > \frac{\alpha_L}{2} \quad \frac{(1 \quad \gamma)\alpha_L^2}{18T}. \qquad (4)$$

We also assume that $\alpha_L > T/2$; that is, α_L is sufficiently large that at zero price, the low-value consumers would purchase the non-perishable. If condition (4) holds, then $\Pi_{SS} < \Pi_{NS}$ when M = 1 as well.[16] Hence, if condition (4) holds, neither firm has an incentive to put the non-perishable on sale (i.e., charge less than α_H) when it was on sale in the previous period, and thus for M = 1, the unique equilibrium is $P_p^1 = P_p^2 = T/(1\text{-}\gamma)$ and $P_N^1 = P_N^2 = \alpha_H$.

Both firms charging α_H for the non-perishable is an equilibrium as long as $\Pi_{NN} > \Pi_{SN}$. However, the number of units of the non-perishable a non-loyal will buys increases with M, so that the incentive to put the non-perishable on sale is generally increasing in M ($\Pi_{S,N}$ / M > 0 for M sufficiently large, and positive for all M if $\gamma < 2/3$).[17] Since Π_{NN} is independent of M, it will eventually be profitable for one of the firms to put the non-perishable on sale. Additionally, because Π_{SS} and Π_{NS} are decreasing in M, there may be more than one equilibrium when M gets large.

Specifically, if $\Pi_{SS} > \Pi_{NS}$ at the M for which $\Pi_{SN} > \Pi_{NN}$ (that is, if one's rival has a sale on the perishable, then it is more profitable to have a sale than to not have a sale), then the unique equilibrium is for both firms to place the non-perishable on sale. In terms of table 2, if $\Pi_{SS} > \Pi_{NS}$, and $\Pi_{SN} > \Pi_{NN}$, the dominant strategy for both players is to put the non-perishable on sale. This creates a kind of prisoner's dilemma; the two retailers are jointly better off with the N,N outcome, but their individual incentives lead to the S,S outcome. In this case, the pattern of prices is for both prices to remain stable for a number of periods (at the N,N levels), then both firms' perishable prices will rise and non-perishable price will decline for one period. All prices then return to the initial levels, and the patterns repeats.

Conversely, if $\Pi_{SS} < \Pi_{NS}$, an alternative equilibrium pricing path may arise. As in the previous case, the N,N equilibrium prices will prevail for a number of periods. In this case, however, when M becomes sufficiently large that $\Pi_{SN} > \Pi_{NN}$, there are three potential equilibria. One equilibrium is for retailer i to put the non-perishable on sale, while retailer j sets $P_N = \alpha_H$. This is an equilibrium, since, given that retailer i has a sale, retailer j's best strategy is to not have a sale, since $\Pi_{SS} < \Pi_{NS}$. There are two equilibria of this form (one with $P_N^1 = \alpha_H$ and $P_N^2 < \alpha_L$ and one with $P_N^2 = \alpha_H$ and $P_N^1 < \alpha_L$). There is also a third equilibrium in which both retailers place the non-perishable on sale with probability R where R solves

$$\frac{R}{1\ \ R} \quad \frac{\Pi_{SN}\ \ \Pi_{NN}}{\Pi_{NS}\ \ \Pi_{SS}}$$

When the mixed strategy equilibrium obtains, there is a probability of R^2 that they both put the non-perishable on sale, while there is a probability of $(1- R)^2$ that neither has a sale on the non-perishable, and a probability of 2R(1-R) that exactly one of them has a sale on the non-perishable. If neither has a sale, then the same three equilibria may arise in the following period.

The empirical implications for prices when $\Pi_{SS} < \Pi_{NS}$ are fairly similar to the implications when $\Pi_{SS} > \Pi_{NS.}$ In both cases, prices for both goods remain constant for a number of periods, followed by a brief time in which prices for the non-perishable are "low" and prices for the perishable are high. One significant difference is that in the case where $\Pi_{SS} < \Pi_{NS}$ it is possible for only one retailer to have a sale on the non-perishable. Hence, in this case, price movements need not be correlated across retailers. Example 1 helps illustrate the pricing dynamics

Example 1: Consider the equilibrium for the following parameter values; $\alpha_H = 3$, $\alpha_L = .75$, $\beta = 2.5$, $\gamma = .4$, and T = 1. When M = 1, the resulting prices and profits are

	Firm 1's prices	Firm 2's prices	Firm 1's profit	Firm 2's profit
N,N	$P_N = 3$, $P_P = 1.66$	$P_N = 3$, $P_P = 1.66$	1.43	1.43
S,S	$P_N = -.83$, $P_P = 2.5$	$P_N = -.83$, $P_P = 2.5$	.83	.83
S,N	$P_N = -.5$, $P_P = 2.42$	$P_N = 3$, $P_P = 1.42$	1.1	1.2

Hence, both retailers charging $P_N = \alpha_H = 3$ and $P_P < \beta$ (that is, N,N) is the unique equilibrium when M = 1. It is also the unique equilibrium when M = 2. However, when M = 3, the resultant prices and profits are

	Firm 1's prices	Firm 2's prices	Firm 1's profit	Firm 2's profit
N,N	$P_N = 3$, $P_P = 1.66$	$P_N = 3$, $P_P = 1.66$	1.43	1.43
S,S	$P_N = -.43$, $P_P = 2.5$	$P_N = -.43$, $P_P = 2.5$	.78	.78
S,N	$P_N = .22$, $P_P = 1.77$	$P_N = 3$, $P_P = .77$	1.56	.85

It follows that when M = 3, N,N is no longer an equilibrium - if its rival is charging $P_N = \alpha_{L,}$ each retailer would find it profitable to instead choose $P_N < \alpha_L$. In this example, since $\Pi_{SS} < \Pi_{NS}$, there are three equilibria; two in which one firm sets $P_N = \alpha_H$ and $P_P < \beta$ and one firm sets $P_N < \alpha_L$ and $P_P = \beta$. The exact prices in these equilibria are presented in the above table. The third equilibrium is the mixed strategy equilibrium. In any of these cases, the price path for each firm is to charge $P_N = 3$, $P_P = 1.66$ for two periods. When M = 3 there are three possible outcomes; two involve one firm lowering P_N and raising P_P, while the other firm lowers P_P and leaves P_N unchanged. In the third equilibrium, one or both firms may lower P_N and raise P_P.

The finding that Π_{SS} is less than Π_{NS} is dependent on the exact parameters chosen. If $\gamma = .25$, rather than .4, as assumed above, the equilibrium path changes. In particular, Π_{SN} becomes greater than Π_{NN} when M = 2, so N, N is only an equilibrium for M = 1. Additionally, at M = 2, Π_{NS} is less than Π_{SS}, which means that at M = 2 the unique equilibrium is S,S.

Example 1 helps illustrates some general principles about the pricing dynamics implied by our model. In particular, it explains why non-perishable goods have regular prices which prevail most of the time, and why deviations from the regular price are primarily downward. At the same time, it explains two aspects of perishable good pricing; why such prices change over time, and why there are mass points in the pricing distribution. The model also has the prediction that prices for the two goods will vary inversely at each individual store. The model also an implication about the relative pricing patterns of perishable and non-perishable products: The range of prices will be smaller for perishables than non-perishables. For example, the change in perishable prices between the N,N and S,N equilibria is smaller than the change in non-perishable prices for all relevant M.

Moving beyond the two-product model, we speculate that the same general pricing principles will apply to food retailers who carry thousands of products. The basic intuition of the model is that retailers use multiple pricing instruments to attract "shoppers,"and some of the those instruments can also be used to price discriminate. To preserve the ability to price discriminate on the non-perishable products, the perishable product will often be sold at "low" prices. Generalizing the model to more than two goods, we note that Lal and Matutes' model of how retailers compete for non-loyal consumers suggests that multiple goods will typically be sold at low prices simultaneously. In their model competition induces firms to offer a given amount of consumer surplus to the non-loyal consumers, and the retailer must offer prices that generate that level of consumer surplus without inducing "cream skimming" by consumers (i.e., consumers buying a different low-priced item from each retailer). Hence, retailers charge low prices for multiple goods in each period. This suggests that in a model of multiple goods of both types, retailers will offer a bundle of goods on sale at any point in time, where the bundle may change from week to week. Some weeks the bundle will feature many non-perishables on sale, and relatively few perishables, and other weeks featuring a greater share of perishables. Thus, while the model predicts the prices of any one perishable and non-perishable should be negatively correlated, we suspect this correlation may not be very strong. A better test of the model would be to construct a bundle containing the perishable and non-perishable products that go on sale and measure the correlation between these bundles. However, as discussed below in more detail, we only have data for one perishable product, so the test we conduct is not very powerful.

IV. Empirical Evidence

Existing empirical evidence suggests that many retail food products (particularly, popular ones) are characterized by relatively long periods of unchanged prices, followed by brief periods of lower prices, and then a return to the initial level. For goods that either are infrequently consumed, or can be readily inventoried by consumers, this pattern of prices can be explained by existing models, as discussed in section II. However, as table 1 indicated, this same pricing pattern seems to characterize goods, such as lettuce, bananas, eggs and cheese, that are both consumed regularly and difficult to inventory. While Varian's model explains why prices may fluctuate for these kinds of products, an explicit prediction of that model is that there are no mass points in the pricing distribution (i.e., no "regular" prices). Yet, empirical tests of the Varian model (see, e.g., Villas-Boas) explicitly reject this prediction in many cases.

However, as the model developed here shows, by taking into account the multi-product nature of food retailers, the existence of regular prices (above the sale level) for perishables can be readily explained.[18] In each period, retailers compete for customers by putting a bundle of goods on sale, where the bundle consists of non-perishables and perishables. In periods in which it is profitable to put many non-perishables on sale (because those non-perishables have not been on sale for many periods), we would expect a larger number of perishables to be at “high” non-sale prices. In this section, we test the model by examining two of its empirical implications. First, we test to see if the average price change is larger for the non-perishable than the perishable when a price change occurs. Second, we examine whether price changes at an individual store between a given perishable and a given non-perishable are negatively correlated.

The data we use to examine these predictions comes from a public use data set provided by A.C. Nielsen.[19] This data set contains daily prices and "category shares" for several categories of goods at the individual store level for two medium-size Midwestern cities (Springfield, MO and Sioux Falls, SD). Ideally, the perishable products would have very short shelf lives, e.g. lettuce, whereas the non-perishables could be stored for a long period of time without deteriorating, e.g. peanut butter. There were many products in the data set that appear to be good candidates as non-perishables,[20] however, there was only one product (margarine) that met our definition of a perishable. While margarine can be stored for a considerable length of time, it is still perishable in that it must be refrigerated to be stored. Because it must be refrigerated, it is more costly to store than truly non-perishable products. Consequently we use margarine as the perishable grocery product. We have chosen peanut butter as the non-perishable product for several reasons: Peanut butter and margarine have similar price points, both margarine and peanut butter have a number of brands with significant value to consumers,[21] and both have similar weekly average consumption. Within these categories, we focused on the three branded product/sizes with the largest market shares. In both of these cities, there were multiple supermarket chains. Prices within each chain were very highly correlated, and consequently each store within each chain cannot be considered an independent observation. For this reason, we construct one price series for each chain. There are 5 chains in Sioux Falls, and 4 chains in Springfield. The data set covers the 124 week period from January 23, 1985 through June 3, 1987. Table 2 presents descriptive statistics from the data set.

Figure 1 presents the pattern of prices for Peter Pan peanut butter in Springfield, while figure 2 presents it for Parkay margarine. The pattern of prices for these two products seem to fit the predictions of the model. Prices for Parkay tend to move over a relatively small range while Peter Pan's prices experience brief but large periodic price reductions (typically lasting one or two weeks).[22] One other pattern can be observed from examining figures 1 and 2; sales do not appear to be correlated across stores. That is, it is rare for two stores in a city to lower Peter Pan price in the same week. To the extent wholesale prices are common to all retailers in a market, this supports the premise, central to testing the model, that retail price changes are largely driven by changes in retail margins, rather than changes in wholesale prices.

We formally test the prediction that discounts will be greater for sales on non-perishable goods than perishable goods by comparing the mean prices of peanut butter and margarine prices conditional on any price increase or decrease.[23] Table 3 presents the average price increase or decrease for the top three brands of peanut butter and margarine conditional on a price change for Springfield, MO and Sioux Falls, SD and the test statistics comparing the price increases and decreases between the two cities. We see that, consistent with the theory, for both cities and both price increases and decreases that peanut butter price changes are larger than margarine price changes. All of these differences are significant at the 1% level.

The second implication we test is that price changes for the two products are negatively correlated within stores. We examine the relationship between margarine and peanut butter price changes using two similar measures. The first involves estimating a simple regression model. We create indicator variables equal to -1 or 1 if the price of any brand of a product decreased or increased, respectively, in a given time period at a given store, and zero if all prices remained the same. We then regress the indicator variable for margarine on the indicator variable for peanut butter.[24] Two versions of the model are estimated; one using all of the observations (models 1 and 2) and one using only those observations where peanut butter price changes (models 3 and 4). The results appear in table 4. As the theory predicts, the coefficient on the peanut butter indicator is negative, and is significant at the .05 level in models 1 and 2 and .1 level in models 3 and 4. The coefficients are about .08 in all 4 cases, which suggests that margarine prices are 4 percent more likely to rise (or fall) in weeks in which peanut butter price fell (or rose) than in other weeks. However, given the weak explanatory power of the model (the R-squared is less than .02 in all specifications), we view these results as providing only moderate support for the model.

Our second method of examine this prediction is to calculate the mean price change of one product given a price increase (or decrease) in the other. Comparing the mean change in margarine prices conditional on a change in peanut butter prices is a better test than the reverse, because while all peanut butter price changes will be associated with margarine price changes, not every margarine price change will be associated with a peanut butter price change (e.g., if the equilibrium changes from N,N to N,S as M increases, both retailers change their perishable price, but only one changes its non-perishable price). The conditional means are presented in table 5. The comparisons of margarine prices conditional on peanut butter price changes are in the direction predicted by the theory, but only the effect associated with peanut butter price increases is statistically significant. As expected, the comparison of peanut butter price changes conditional on a margarine price change is less clear. Margarine price decreases are associated with statistically significantly higher peanut butter prices, consistent with the theory. However, conditional on a lower margarine price, peanut butter prices are slightly lower, contrary to the theory (although the effect is not statistically significant). Again, these results provide some modest support for the theory.

Finally, we examined the empirical validity of the assumption that price changes represent changes in retail margins, rather than changes in wholesale price. We test this by looking at the correlation of price changes across stores for a given product. Under the assumptions that (1) prices to retailers (wholesale prices) move together in each city, and (2) wholesale price changes are reflected in retail prices changes with a lag that is common across all retailers, we would expect to see retail price changes that are highly correlated if sales were primarily driven by wholesale price changes.[25] As figures 1 and 2 suggests, retail price changes are not highly correlated. Tables 6a-b show the correlations of price changes across stores for the six products in Sioux Falls (Springfield available from authors). Nearly half of the correlations are negative, and only 3 of the 60 are greater than .25. This suggests that retail price changes were not primarily driven by changes in wholesale prices.

While we have not been able to test all of the model's implications, the tests we did perform lend empirical support for two of the model's key predictions. When there is a price change, the absolute value of the average price change is always larger for the non-perishable than the perishable. In addition, the evidence suggests that peanut butter and margarine prices changes are negatively associated. Further, because the contemporaneous correlations of price changes of individual items across stores were typically small (and sometimes negative), it appears safe to conclude that most of the grocery store price changes we observe for peanut butter and margarine are the result of retailers changing margins, rather than manufacturers changing wholesale prices. Together, this evidence indicates sale behavior is an important aspect of retail competition and likely the greatest cause of the observed variation in retail prices. It appears to be the case that retailers pursue different pricing strategies for different types of grocery items, likely related to product characteristics.

V. Conclusion

This paper analyzes one aspect of the competition between multi-product retailers. We consider how retailers adjust price over time to take advantage of differences across consumers while simultaneously competing with rivals. We show that these two objectives result in price movements for all goods; even those for which discriminating between consumers is not a goal of the retailer. The model yields predictions for price movements which conform to recent empirical findings, as well as causal observation. At the same time, the model yields a variety of additional, testable implications. For example, the theory predicts a negative correlation between perishable and non-perishable prices at a specific supermarket.

We examined this and several other implications using publicly-available pricing data. Consistent with the theory, prices for the non-perishable (peanut butter) and the perishable good (margarine) seem to be negatively correlated. In addition, when price changes occur, they are larger in magnitude for the non-perishable.

We view this evidence as suggesting that price discrimination by intertemporal price changes is one function served by sales in the food retailing industry. In addition to providing us with an understanding of how retailers compete, this view of retail competition has several important policy implications. For example, to the extent our findings are confirmed in future work, it would have several implications for merger analysis. One relates to the correct interpretation of demand elasticities derived from scanner data. Estimates of brand-specific elasticities and cross-elasticities have become a common component of the Federal Trade Commission and U.S. Department of Justice merger review process. Evidence regarding these elasticities is often presented to the agencies by representatives of the merging parties or an interested third party in order to demonstrate the likely consequences of combining two competing brands of a product (e.g. canned soup) under common ownership. The data used in such estimation is typically weekly scanner data on transaction prices and quantities. Such elasticities can be thought of as *purchasing* elasticities; the responsiveness of consumer's buying patterns to changes in prices. If inventorying by consumers is important, these elasticities can be quite different from *consumption* elasticities and it is the latter elasticities which are relevant to merger analysis. For example, if the scanner data covers a period in which a retail price moves between a *regular* price and a *sale* price, then the measured elasticity will reflect purchases by individuals who buy at sale prices and then inventory a non-perishable item (e.g. canned soup or peanut butter) for consumption during the non-sale periods. Even if every individual had a completely inelastic consumption demand, such a study might well demonstrate a significant purchasing elasticity. What is relevant for a merger among manufacturers, however, is what would happen if the entire price schedule changed, and this is not measured by the purchasing elasticity.

The second point is relevant for analyzing mergers among retailers. Suppose inter-retailer competition affects the frequency and depth of sales rather than the level of non-sale prices. Then, evaluating the effect of a merger based on comparing prices during narrow pre- and post-merger windows will provide, at best, a noisy measure of the effect of a merger. If many of the items chosen for comparison are those that are infrequently used as sale items, then we may find little or no price effect of the merger. For example, in the Lal and Matutes model, retailers always charge the monopoly price for items that are never advertised, regardless of market structure. Hence, one would observe no effect of mergers on prices of these goods, regardless of whether the merger reduces retail competition. Moreover, even if all of the items in the sample are those often subject to sales, if one compares prices in a narrow time window following a merger to a similar pre-merger period, one might find significant numbers of both price reductions and price increases, even if the merger reduces competition. In such an environment, a researcher must be careful when constructing the price index used to determine if a merger led to higher prices.

References

Banks, Jeffrey and Sridhar Moorthy (1999) “A Model of Price Promotions with Consumer Search,” *International Journal of Industrial Organization*; 17, pp. 371-98.

Conlisk, John, Eitan Gerstner, and Joel Sobel (1984) "Cyclic Pricing by a Durable Goods Monopolist," *Quarterly Journal of Economics;* 99, pp. 489-505

Hosken, Daniel, David Matsa and David Reiffen (2000) “How do Retailers Adjust Prices: Evidence From Store-Level Data” Working Paper # 230, Federal Trade Commission

Hosken, Daniel and David Reiffen (1999) “Pricing Behavior of Multi-Product Retailers,” Working Paper #225, Federal Trade Commission

Lal, Rajiv and Carmen Matutes (1994) "Retail Pricing and Advertising Strategies," *Journal of Business*; 67, pp. 345-70.

B. Peter Pashigian (1988) "Demand Uncertainty and Sales: A Study of Fashion and Markdown Pricing," *American Economic Review;* 78, pp. 936-53.

___ and Brian Bowen (1991) "Why are Products Sold on Sales?: Explanations of Pricing Regularities," *Quarterly Journal of Economics*; 106, pp.1014-1038.

Pesendorfer, Martin (1997) "Retail Sales: A Study of Pricing Behavior in Super Markets" Mimeo.

Sobel, Joel (1984) "The Timing of Sales," *Review of Economic Studies*; 51, pp. 353-68.

Varian, Hal R. (1980) "A Model of Sales", *American Economic Review*; 70, pp. 651-9.

Villas-Boas, J. Miquel (1995) “Models of Competitive Price Promotions: Some Empirical Evidence from the Coffee and Saltine Cracker Market” *Journal of Economics and Management Strategy*, 4, pp. 85-107.

Warner, Elizabeth J. and Robert B. Barsky (1995) “The Timing and Magnitude of Retail Store Markdowns: Evidence from Weekends and Holiday,” *Quarterly Journal of Economics*; 110, pp. 321-52.

White, H. (1980) “A Heteroscedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroscedasticity” *Econometrica*; 48., pp. 817-38.

Table1:Percentage of Prices at Annual Modal Price, and Ratio of Deviation Below Modal Price to Deviations above Model Price, By Product

Product Category	Proportion at Mode[i]	Ratio of Price Decrease to Price Increases	Z-Statistic (P value)
Baby Food	74.0% (592)	1.75	3.95 (.0000)
Bananas	57.9% (3371)	2.01	15.88 (.0000)
Canned Soup	69.1% (2615)	1.93	10.81 (.0000)
Cereal	68.1% (2885)	1.75	9.85 (.0000)
Cheese	67.5% (3238)	1.54	8.15 (.0000)
Snacks	75.8% (1453)	2.46	9.40 (.0000)
Cola Drinks	65.9% (1872)	2.24	11.80 (.0000)
Cookies	73.6% (1049)	2.38	8.09 (.0000)
Crackers	66.5% (516)	3.29	8.66 (.0000)
Eggs	42.0% (5795)	1.27	8.55 (.0000)
Frozen Dinners	70.7% (552)	2.77	7.24 (.0000)
Frozen Orange Juice	60.2% (1560)	2.24	11.86 (0000)
Ground Beef	62.6% (2996)	2.17	15.22 (0000)

Hotdogs	65.5% (908)	2.38	8.92 (0000)
Lettuce	16.8% (4206)	3.57	53.84 (0000)
Margarine	65.5% (1222)	2.11	8.95 (0000)
Paper Products	68.5% (602)	2.42	6.94 (0000)
Peanut Butter	66.3% (984)	1.93	7.03 (0000)
Soap and Detergents	70.5 (832)	2.39	7.79 (0000)
White Bread	71.4 (2462)	1.70	8.11 (0000)

i Number of observations in parentheses.

Table 2: Descriptive Statistics

Variable	Sioux Falls, South Dakota	Springfield, Missouri
Price of Blue Bonnet 4 Pack Stick Margarine	0.569 (0.086) [599]	0.618 (0.088) [495]
Price of Fleischman 4 Pack Stick Margarine	1.15 (0.098) [588]	1.08 (0.077) [495]
Price of Parkay 4 Pack Stick Margarine	0.572 (0.087) [601]	0.589 (0.110) [496]
Price of 18 Ounce Jif Creamy Peanut Butter	1.74 (0.160) [596]	1.84 (0.212) [495]
Price of 18 Ounce Peter Pan Creamy Peanut Butter	1.76 (0.204) [577]	1.78 (0.246) [496]
Price of 18 Ounce Skippy Creamy Peanut Butter	1.68 (0.117) [571]	1.84 (0.228) [495]
Number of Chains	5	4
Number of Weeks	124	124

Standard Deviations is in parentheses, number of observations in brackets, and prices in dollars.

Table 3: Test Statistics for Comparisons of Margarine and Peanut Butter Sales Behavior in Sioux Falls, South Dakota and Springfield, Missouri.

Test	Mean Margarine	Mean Peanut Butter	T-Statistic
Average Price Increase for Margarine and Peanut Butter are Equal in Sioux Falls	12.87	18.42	5.01
Average Price Decrease for Margarine and Peanut Butter are Equal in Sioux Falls	-12.79	-19.31	5.07
Average Price Increase for Margarine and Peanut Butter are Equal in Springfield	14.79	29.26	6.06
Average Price Decrease for Margarine and Peanut Butter are Equal in Springfield	-15.31	-26.01	4.02

Table 4: Regress Indicator of Change in Margarine Price on Indicator of Change in Peanut Butter Price

Variable	Model 1	Model 2	Model 3	Model 4
Intercept	0.00766 (0.030)	-0.00106 (0.023)	-0.0371 (0.0557)	-0.0246 (0.0419)
Peanut	-0.0829 (0.0417)	-0.0826 (0.0417)	-0.0793 (0.0418)	-0.0797 (0.0419)
Springfield Indicator	-0.0188 (0.0446)		0.0289 (0.0838)	
R-squared	0.0044	0.0042	0.0127	0.0123
observations	971	971	290	290
Include Observations with no change in Peanut Butter Prices	yes	yes	no	no

Standard Errors are in parentheses. The standard errors are corrected for arbitrary heteroscedasticity (see White).

Table 5: Change in Margarine or Peanut Butter Price
Conditional on a Peanut Butter or Margarine Price Increase or Decrease

	Mean Change	Observations
Mean Change in Margarine Price Conditional on a Peanut Butter Price Increase	-2.595 (11.914) [-2.781]	163
Mean Change in Margarine Price Conditional on a Peanut Butter Price Decrease	0.464 (12.178) [0.430]	127
Mean Change in Peanut Butter Price Conditional on a Margarine Price Increase	0.284 (17.122) [0.253]	232
Mean Change in Peanut Butter Price Conditional on a Margarine Price Decrease	2.644 (19.152) [2.121]	236

Standard Deviations are in parentheses, t-test that change in price is different from zero is in brackets.
Note that the unconditional mean change for both peanut butter and margarine prices is essentially zero.

Table 6a
Correlations of Peanut Butter Changes Across Chains in Sioux Falls, South Dakota

Brand Name		Chain 1	Chain 2	Chain 3	Chain 4	Chain 5
18 Ounce Jif Creamy Peanut Butter	Chain 1	1.000	-0.115	0.090	0.000	-0.296
	Chain 2	-0.115	1.000	-0.003	-0.204	-0.001
	Chain 3	0.090	-0.003	1.000	0.006	0.225
	Chain 4	0.000	-0.204	0.006	1.000	-0.092
	Chain 5	-0.296	-0.001	0.225	-0.092	1.000
18 Ounce Peter Pan Creamy Peanut Butter	Chain 1	1.000	0.429	0.206	0.021	0.009
	Chain 2	0.429	1.000	0.034	0.045	-0.058
	Chain 3	0.206	0.034	1.000	-0.168	0.090
	Chain 4	0.021	0.045	-0.168	1.000	0.062
	Chain 5	0.009	-0.058	0.090	0.062	1.000
18 Ounce Skippy Creamy Peanut Butter	Chain 1	1.000	0.266	-0.001	-0.416	-0.094
	Chain 2	0.266	1.000	0.031	0.404	0.230
	Chain 3	-0.001	0.031	1.000	0.000	0.000
	Chain 4	-0.416	0.404	0.000	1.000	0.223
	Chain 5	-0.094	0.230	0.000	0.223	1.000

Table 6b
Correlations of Margarine Price Changes Across Chains in Sioux Falls, South Dakota

Brand Name		Chain 1	Chain 2	Chain 3	Chain 4	Chain 5
Parkay 4 Pack Stick Margarine	Chain 1	1.000	-0.015	0.054	0.147	0.077
	Chain 2	-0.015	1.000	-0.024	-0.279	-0.098
	Chain 3	0.054	-0.024	1.000	0.057	0.020
	Chain 4	0.147	-0.279	0.057	1.000	-0.050
	Chain 5	0.077	-0.098	0.020	-0.050	1.000
Blue Bonnet 4 Pack Stick Margarine	Chain 1	1.000	0.168	-0.001	0.000	0.045
	Chain 2	0.168	1.000	0.179	-0.010	0.007
	Chain 3	-0.001	0.179	1.000	-0.161	-0.026
	Chain 4	0.000	-0.010	-0.161	1.000	0.194
	Chain 5	0.045	0.007	-0.026	0.194	1.000
Fleischman 4 Pack Stick Margarine	Chain 1	1.000	0.025	0.226	-0.286	0.090
	Chain 2	0.025	1.000	0.000	-0.013	-0.229
	Chain 3	0.226	0.000	1.000	-0.017	0.057
	Chain 4	-0.286	-0.013	-0.117	1.000	0.252
	Chain 5	0.090	-0.229	0.057	0.252	1.000

Figure 1: Time Series of Shelf Prices of Peter Pan Peanut Butter in Springfield, MO

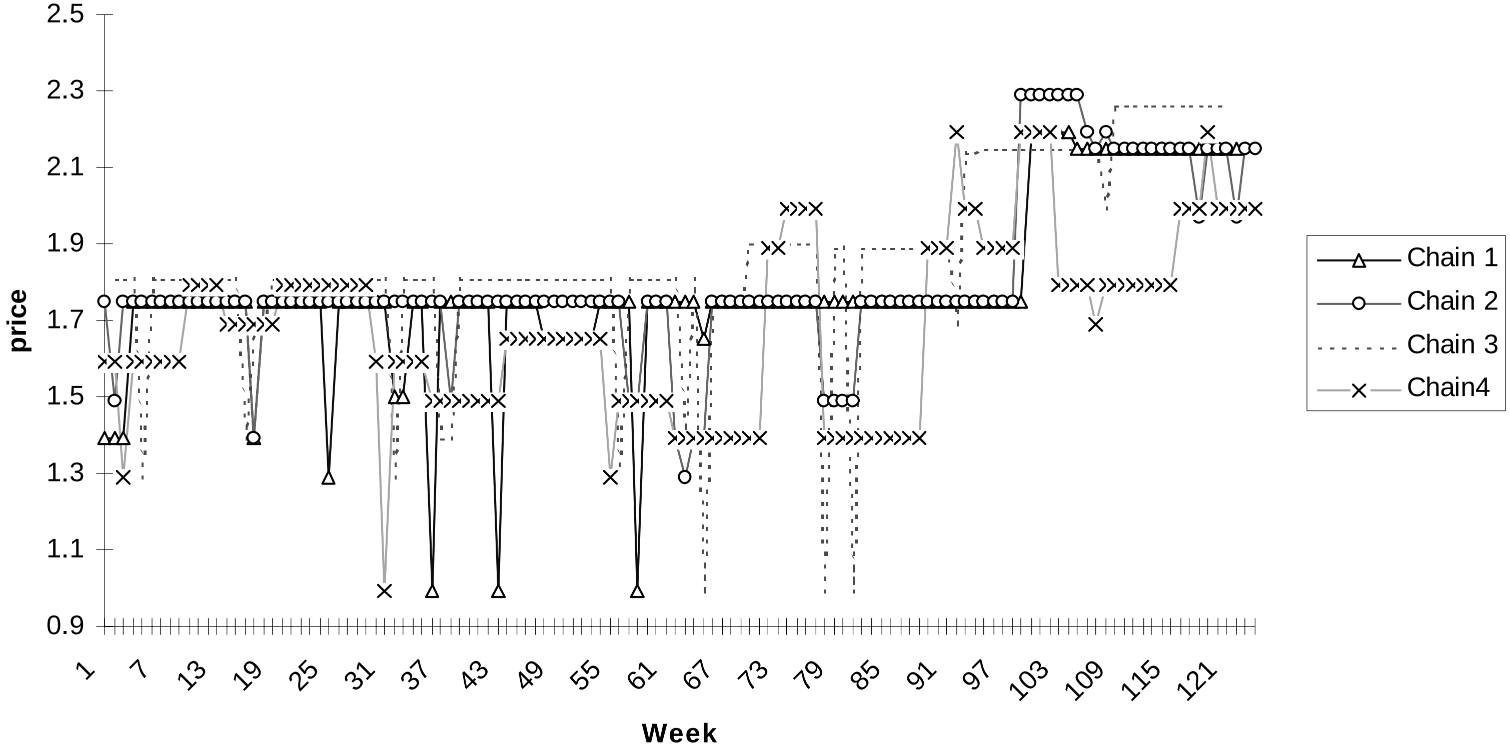

Figure 2: Time Series of Shelf Prices of Parkay Margarine in Springfield, MO

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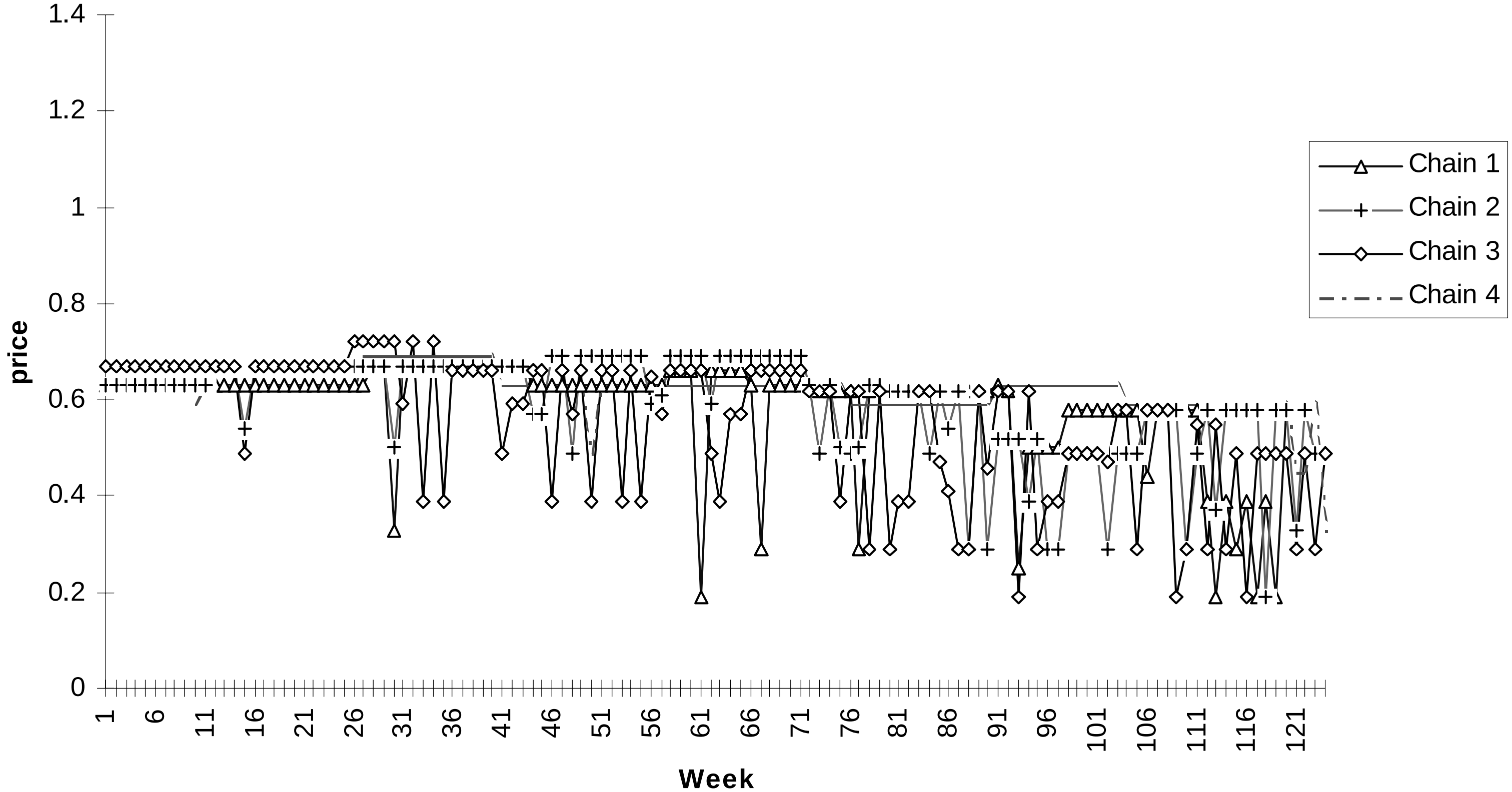

Endnotes

1. Recent examples of government antitrust actions against distributors include litigations to stop mergers in the office supply retailing (*FTC v. Staples Inc.* in 1997), and drug wholesaling industries (*FTC v. Cardinal Health, Inc.*, and *FTC v. McKesson Corp*. in 1998).

2. We use the term *sale* to refer to a temporary reduction in the price of an item which is unrelated to cost changes. The price reduction is temporary in that consumers know that the retailer will raise his price in the near future.

3. Peanut butter fits our notion of non-perishable very well, while stick margarine is somewhat further from our ideal perishable, but was the closest among the products for which data were available.

4. Another pricing pattern that is sometimes referred to as a sale is a "markdown", whereby price reductions occur, but are not reversed; instead the price decline escalates over a fashion season. Pashigian, and Pashigian and Bowen documents this phenomenon for apparel, and Warner and Barsky provide additional evidence. Markdowns of this kind are not the pattern we are trying to explain in this paper.

5. One can interpret the Conlisk, et al. result as providing an economic explanation for the famous retailing cliche "to make it up in volume."

6. The same general model has been used to explain the use of targeted price cuts (e.g., manufacturer coupons). In Banks and Moorthy, high and low value consumer differ in their costs of obtaining the price discount (e.g., the cost of using coupons), rather than in their willingness to wait/inventory. Given the differential search cost, a coupon is a means of offering low prices to low-value/ low search cost consumers while simultaneously charging high prices to high-value consumers.

7. In contrast, in Sobel's model, low-value consumers may wait to buy, even if price is below α_L, if they expect price to fall further. Sobel shows that the expected price decline eventually dissipates, and that consumers rationally purchase the good. Thus, the qualitative predictions of the Pesendorfer version are similar to Sobel's results.

8. This formal equivalence require that low-value consumers have some inventory at the beginning of period 1, and that when price is below α_L, these consumers buy a sufficient quantity for storage to replace the inventory consumed since the previous sale. These assumptions are discussed further in Section III.

9. As discussed below, this prediction seems to fit the actual pattern of pricing found in empirical research.

10. More precisely, this pricing pattern will hold for goods for which inventory costs differ across consumers, where the inventory costs are positively correlated with willingness to pay. These are likely to be goods that are easy to store. A primary reason that there would be a positive correlation between inventory costs and willingness to pay is that consumers with higher income/time costs will have both a higher willingness to pay and a lower willingness to undertake the transactions costs required to inventory the good. Products for which transaction costs of inventorying are an important component of total inventory costs are those for which other costs of inventorying are low (i.e., for items readily stored at home, such as canned tuna). Hence, a positive correlation is most likely for goods with low storage costs. In contrast, if there are large difference in inventorying costs but those costs are not correlated with willingness to pay, those items will not be put on sale.

11. We have also solved the model assuming all non-loyals shop at the low priced retailer. See Hosken and Reiffen.

12. Lal and Matutes model competition between multi-product retailers in this way.

13. If $P_P > \beta$ (or $P_N > \alpha_H$), then retailer j makes no sales of the perishable (non-perishable). Hence, we restrict the analysis to values of $P_N \leq \alpha_H$ and $P_P \leq \beta$.

14. Following Pesendorfer, we assume that the decision rule of low-value consumers is to buy the non-perishable whenever $P_N < \alpha_L$. Clearly, the assumption that consumers exactly replace their depleted inventory is not derived from a model of optimal consumer inventory behavior. This omission is not critical in that the only property of inventory behavior that is required for our results is that when a *sale* occurs, aggregate purchases of the good by low-value consumers is increasing in the length of time since the previous *sale*. This property holds for some simple inventory models that we investigated. For this reason, our model does not require identical inventorying behavior by all low-value consumers.

15. It can be shown that $P_p^1 = \beta$ and $P_N^1 = \alpha_H$, is less profitable than $P_p^1 = \beta - \varepsilon$ (for some ε) and $P_N^1 = \alpha_H$ as long as γ is less than 1.

16. $\Pi_{SS} < \Pi_{NS}$ for M = 1 requires $\gamma\, \alpha_H > 2\, \alpha_L/3$, which necessarily holds if (4) holds..

17.

$$\frac{\Pi_{S,N}}{M} \quad \frac{\gamma}{2}[\quad \frac{\alpha_L}{3} \quad \frac{T}{M^2}(1 \quad \frac{2\gamma}{3(1 \quad \gamma)}(\frac{1}{M} \quad 1)]$$

$$(1 \quad \gamma)[(\frac{1}{2} \quad \frac{M\alpha_L}{6T} \quad \frac{\gamma}{6(1 \quad \gamma)}(\frac{1}{M} \quad 1)(\frac{\alpha_L}{3}) \quad (\frac{\alpha_L}{3T} \quad \frac{\gamma}{6(1 \quad \gamma)M^2})(T \quad \frac{M\alpha_L}{3} \quad \frac{\gamma T}{1 \quad \gamma})$$

Given $\alpha_L >$

T/2, this is positive for all M if $\gamma < 2(1-\gamma) \Leftrightarrow \gamma < 2/3$.

18. In fact, the mass point in the distribution of perishable prices occurs in the multi-goods model even where all shoppers are homogeneous, and buy from the retailer that offers the largest consumer surplus (see Hosken and Reiffen).

19. The data can be found at the ftp site: gsbper.uchicago.edu.

20. These included peanut butter, ketchup, canned tuna, sugar and facial tissue.

21. There are only two significant brands of ketchup, and one brand of sugar.

22. Pesendorfer finds a similar pricing pattern for ketchup.

23. The appropriate measure of discount is the absolute price reduction (rather than percentage) since the model implies that non-loyal consumers choose among supermarket based on the absolute comparison of total expenditures.

24. We also include an indicator for stores in Springfield, Missouri, however, it is never significant and its inclusion does not affect the coefficient on the peanut butter indicator.

25. The assumption that in each city all retailers' wholesale prices move together is based on our understanding of industry practices, along with legal restrictions on differential pricing due to the Robinson-Patman Act. Finally, to the extent that the assumption is incorrect, it would suggest that manufacturers, rather than retailers, were attempting to exploit differences among consumers. Such behavior by manufacturers would be similar to the behavior of retailers in our model.